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(54) Stator and assembly method

(57) A stator disk of an electric motor stator, comprising a set of recesses (212), each recess (212) being configured to a receive a cooling pipe (214). The stator disk (200A) comprises one or more positioning elements (218A) for aligning the stator disk with another stator disk, the one or more positioning elements being positioned to the stator disk (200A) such that when the stator disk (200A) is set to a rotated position with respect to another similar stator disk (200B) to align the recesses (212B, 222A) of the disks (200A, 200B) for receiving of cooling pipes, the positioning elements (218A, 218B) of the two disks (200A, 200B) become only partly aligned with each other.

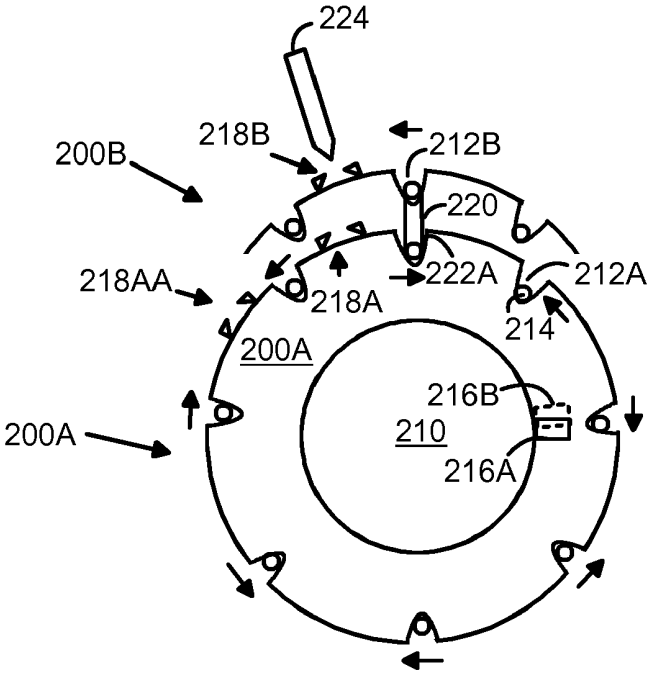

Fig.2

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Description

FIELD

[0001] The present invention relates to electric motors and specifically to the cooling of the stator.

BACKGROUND

[0002] In an electric motor, a rotatable rotor is arranged within/around a stationary stator. The mechanical losses associated to the rotation, such as friction force in bearings, the copper losses affected by the electric current running through the resistance of the windings and the iron losses generated by the magnetic flux cause heat generation during operation. In order to avoid overheating, and to improve the efficiency of the motor, cooling of the motor needs to be provided.

[0003] For the cooling of the motor, liquid and/or gas cooling can be arranged. Patent application US 2009/0160269 A1 shows how the cooling pipes can be arranged to the stator.

[0004] A challenge in arranging the cooling is how to attach properly the cooling pipes, proper attachment being needed to avoid noise and breakage of the pipes when the motor is in operation.

[0005] It is known to use gluing to the fastening of the cooling pipes to the groove of the stator. However, gluing destroys or at least weakens the metallic contact between the cooling pipe and the stator, which deteriorates the cooling effect.

[0006] It is also known to cast the cooling channels directly to the body of the motor. Such a solution is, however, not cost-effective.

SUMMARY

[0007] An object of the present invention is thus to provide a method and an apparatus for implementing the method so as to alleviate the above disadvantages.

[0008] The objects of the invention are achieved by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

[0009] The invention allows the cooling pipes to be tightly mounted to the stator of the electric motor, thereby reducing noise generation and the risk of breakage during operation of the motor.

DRAWINGS

[0010] In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 highlights a stator;
Figure 2 shows an embodiment of a stator cooling arrangement; and
Figure 3 shows one embodiment of a method.

DESCRIPTION OF EMBODIMENTS

[0011] Figure 1 illustrates a prior art stator 100. In the stator, there are provided slots 102 around which conducting wire is wound to form coils. When electricity is supplied to the coils in a rotating manner, a rotating magnetic field is achieved causing the rotor, equipped with squirrel cage windings and/or permanent magnets to rotate.

[0012] The stator is stacked from stator segments 106 comprised of stator disks. Bands 104 may be provided to attach the segments to each other by welding, for instance. No cooling is associated with the stator of Figure 1.

[0013] Figure 2 shows an embodiment for cooling the stator 200, which is stacked from stator segments or disks such as 200A, 200B. The stator may comprise tens or hundreds of stator disks, which preferably are similar to each other.

[0014] In Figure 2, U-shaped recesses 212 are provided on the outer edge of the stator disks 200A, 200B. To each recess, a cooling pipe 214 is placed for conveying the cooling medium, such as liquid or gas. The figure also shows positioning elements 218A, 218B of the respective disks 200A, 200B. In the figure, the recesses 212A and 212B correspond to each other, that is, when those recesses are aligned with each other, the two disks 200A, 200B are fully aligned with each other. When the two disks are fully aligned with each other, also all the positioning elements of the two disks are fully aligned with each other.

[0015] In the situation of Figure 2, the disk 200B is rotated counter-clockwise such that the mutually corresponding recesses 212A and 212B become misaligned with each other. However, the recess 212B becomes aligned with the next recess of disk 200A, that is 222A. When the recesses 212B and 222A are aligned with each other, it is possible to place the cooling pipe to the straight cooling channel formed by the two recesses and corresponding recesses of other stator disks.

[0016] When all the cooling pipes have been placed to the respective cooling channels formed by the recesses of the disk, the mutual positioning of the disks starts. Before the positioning, the positioning elements 218A, 218B are misaligned with each other. Also the coil slots of the stator disks are misaligned with each other. Figure 2 shows two corresponding slots, 216A and 216B of the respective disks 200A and 200B which have become misaligned when the pipe 220 has been placed to the cooling channel.

[0017] To perform the positioning, a positioning member, such as the positioning band 224, is protruded to the positioning elements. This has the effect that the positioning elements 218A, 218B become aligned with each other and also the coil slots 216A, 21 B become aligned with each other.

[0018] However, the recesses 212B and 222A, which were aligned with each other before the rotation, become misaligned with each other. The recesses then exert a pressing force on the cooling pipe 220 placed to the cooling channel. The pressing force is indicated in Figure 2 with arrows at the recesses showing the direction towards which the cooling pipe is pressed. For instance, the recess 222A presses the pipe to the right, whereas the recess 212B of the disk 200B presses the pipe 220 to the left. This way the neighbouring disks exert opposite forces on the disks thereby keeping the pipe 220 tightly in its place.

[0019] It is evident that Figure 2 shows only one way of implementation and many of the features shown may be implemented in an alternative way. For instance, when stacking the disks together, the mutual rotation of the disks may be carried out in several ways. For instance, every other disk may have the same rotation. Thus, odd numbered disks may remain unrotated, and even numbered disks may be rotated counter-clockwise the angle of one recess interval as is the case with disk 200B in Figure 2. The rotation angle may also be 180 degrees or some other suitable angle. Furthermore, the rotation does not need to be carried out one disk at a time. Alternatively, for instance, a sub-stack of disks, such as 5 neighbouring disks, may have the same rotation. The next 5 disks may have the same rotation, and so on.

[0020] The recesses, such as 212A and 212B, do not need to be recesses on the outer edge of the stator disk. Alternatively, the recesses for receiving the cooling pipes may be through holes on the disks. The positioning member in that case may be a pin that fits into the holes of the disks. In that case, as also in the embodiment of Figure 2, the positioning member advantageously has a wedge-shaped head such that it is possible to press the positioning member to the positioning elements and cause the rotation of the disk to achieve alignment of the disks.

[0021] A stator disk comprises one or more positioning elements for aligning the stator disk with another stator disk, the one or more positioning elements being positioned to the stator disk such that when the stator disk is set to a rotated position with respect to another similar stator disk to align the recesses of the disks for receiving of cooling pipes, the positioning elements of the two disks become only partly aligned with each other. The "rotated position" here refers to a situation, where the disks are not fully aligned with other. In a fully aligned situation, all the recesses and positioning elements are aligned with each other. The "rotated position", however requires that the recesses of the disks are aligned in such a way that the cooling pipes can be placed into the recesses. Furthermore, the positioning elements of the disks are not fully overlapping but are in such a way overlapping that the positioning member can be put into the positioning elements of the disks to align the positioning elements.

[0022] When the situation is examined after the positioning member has been put into the positioning elements, the positioning elements in the disk are positioned such that when the stator disk is set to a rotated position with respect to another similar stator disk, the coil slots of the disks become aligned with each other, and the cooling pipes are placed into the recesses and the recesses of mutually rotated disks hosting a cooling pipe cause essentially opposite pressing forces on the cooling pipe.

[0023] Figure 3 shows one embodiment of a method.

[0024] In 300, a plurality of similar stator disks that are to be stacked to a stator, are provided. In the stator disks, there is at least some unevenness or non-symmetry in the distribution of the positioning elements. This results in that when two similar disks are taken, there is only a limited number of rotation positions in which all the positioning elements of the disks are fully aligned with each other. This limited number of positions is smaller than the number of positioning elements in the disks. Preferably, there is only one such rotation position.

[0025] In 302, at least some of the disks are rotated with respect to the other disks. The rotation may be carried out in several ways. The rotation may be carried out disk by disk or sub-stacks of disks may be rotated. A sub-stack may comprise five disks, for instance. The first sub-stack would have one rotation position, the second sub-stack would have another rotation position, and so on.

[0026] In 304, the cooling pipes are placed into the recesses. At this stage, the cooling channels formed by the aligned recesses are straight such that placing of the cooling pipes into the recesses is easy. When the cooling pipes have been placed into the recesses of the mutually rotated disks, the positioning elements provided in the disks become misaligned with each other. Also the coil slots of the disks are at this stage misaligned with each other.

[0027] In 306, the positioning member is placed into the positioning elements of the disks. This causes the positioning elements of the disks to become aligned with each other and also the coil slots of the disks to become aligned with each other.

[0028] A further effect is that the mutually rotated disks cause opposite forces on the cooling pipes, thereby providing a tight fastening of the pipes to the cooling channels formed by the recesses.

[0029] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. A stator disk of an electric motor stator, comprising:

a set of recesses (212), each recess (212) being configured to a receive a cooling pipe (214),

characterized in that
the stator disk (200A) comprises one or more positioning elements (218A) for aligning the stator disk with another stator disk, the one or more positioning elements being positioned to the stator disk (200A) such that when the stator disk (200A) is set to a rotated position with respect to another similar stator disk (200B) to align the recesses (212B, 222A) of the disks (200A, 200B) for receiving of cooling pipes, the positioning elements (218A, 218B) of the two disks (200A, 200B) become only partly aligned with each other.

2. A stator disk according to claim 1, **characterized in that** when the positioning elements (218A, 218B) are aligned with other, a pair of recesses (212B, 222A) of the disks hosting a same cooling pipe (220) cause essentially opposite pressing forces on the cooling pipe (220) .

3. A stator disk according to claim 1, **characterized in that** the positioning element (218A, 218B) is configured to receive a positioning member (224) for alignment of the positioning elements (218A, 218B) of the disks (200A, 200B) to each other.

4. A stator disk according to claim 1, **characterized in that** the stator disk comprises coil slots (102), which coil slots (102) become misaligned with coil slots of a similar stator disk when the two disks are in a rotated position while the recesses of the disks are aligned with each other for receiving a cooling pipe therein.

5. A stator disk according to claim 1, **characterized in that** the recess (222A) for receiving the cooling pipe (220) is a groove on the outer edge of the stator disk (200A).

6. A stator disk according to claim 1, **characterized in** t h a t the recess for receiving the cooling pipe is a through hole in the body of the stator disk.

7. A stator of an electric motor, comprising:

a plurality similar stator disks stacked together to form the stator, wherein each stator disk comprises
a set of recesses, each recess being configured to a receive a cooling pipe,
characterized in that
each stator disk (200A, 200B) comprises one or more positioning elements (218A, 218B) for aligning the stator disks (200A, 200B) together, which one or more positioning elements (218A, 218B) are positioned to the stator disks (200A, 200B) such that when two stator disks are set to a rotated position with respect each other to align the recesses (222A, 212B) of the disks (200A, 200B) for receiving a cooling pipe (220), the positioning elements (218A, 218B) of the two disks (200A, 200B) become only partly aligned with each other.

8. A stator according to claim 7, **characterized in that** the positioning elements (218A, 218B) are partly overlapping such that it is possible to penetrate a positioning member (224) to the positioning elements (218A, 218B) to align the positioning elements (218A, 218B) to each other.

9. A stator according to claim 8, **characterized in that** the when the positioning member (224) is positioned to the positioning elements (218A, 218B) for alignment of the positioning elements (218A, 218B) with each other, the recesses (222A, 212B) of the mutually rotated disks (200A, 200B) are configured to exert essentially opposite pressing forces to the cooling pipes (220) positioned therein.

10. A stator according to claim 7, **characterized in that** before positioning the positioning member (224) to the positioning elements (218A, 218B) of the disks (200A, 200B), the coil slots of the mutually rotated disks are misaligned with each other.

11. A method of mounting a stator of an electric motor, **characterized by**
providing (300) a plurality of similar stator disks, each disk comprising recesses for receiving cooling pipes, and one or more alignment elements for alignment of the disk to other stator disks,
rotating (302) at least some of the stator disks with respect to other stator disks to a rotated position such that the recesses of the mutually rotated disks are aligned, and the positioning elements are misaligned with each other;
placing (304) the cooling pipes to the recesses; and
aligning (306) the positioning elements with each other such that the recesses of the mutually rotated disks cause opposite pressing forces to the cooling pipes.

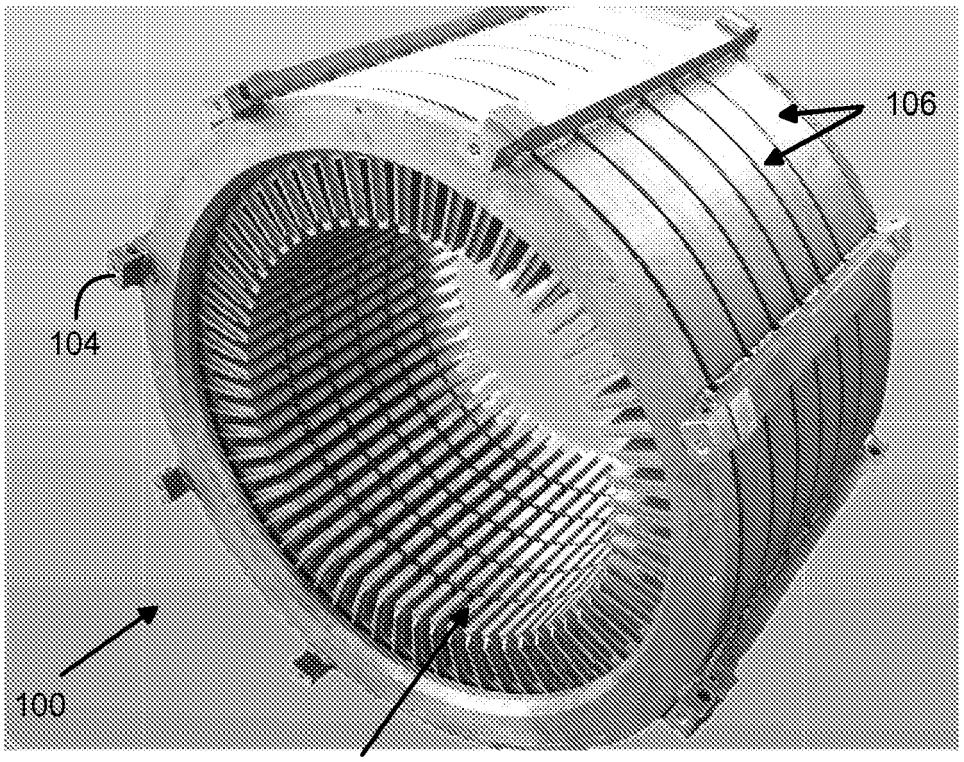
106
104
100
102

Fig.1

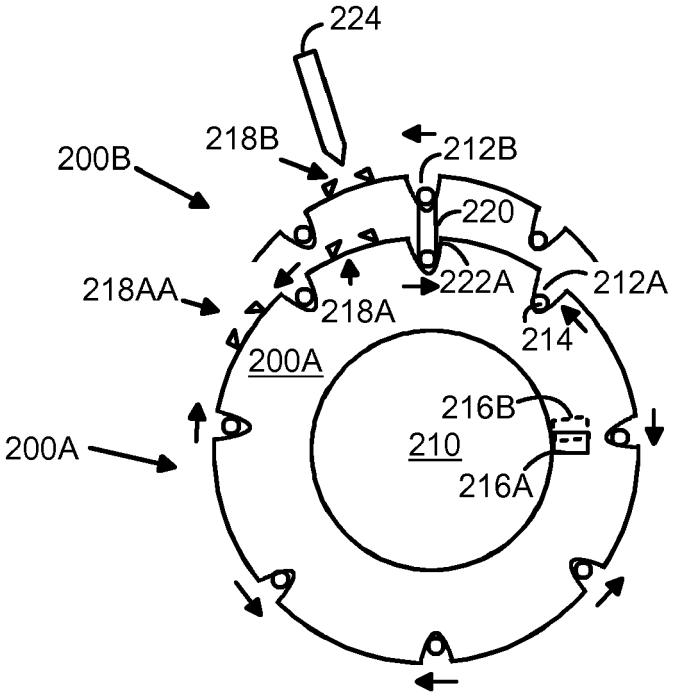
224
218B
212B
200B
220
218AA
222A
212A
218A
214
200A
216B
210
200A
216A

Fig.2

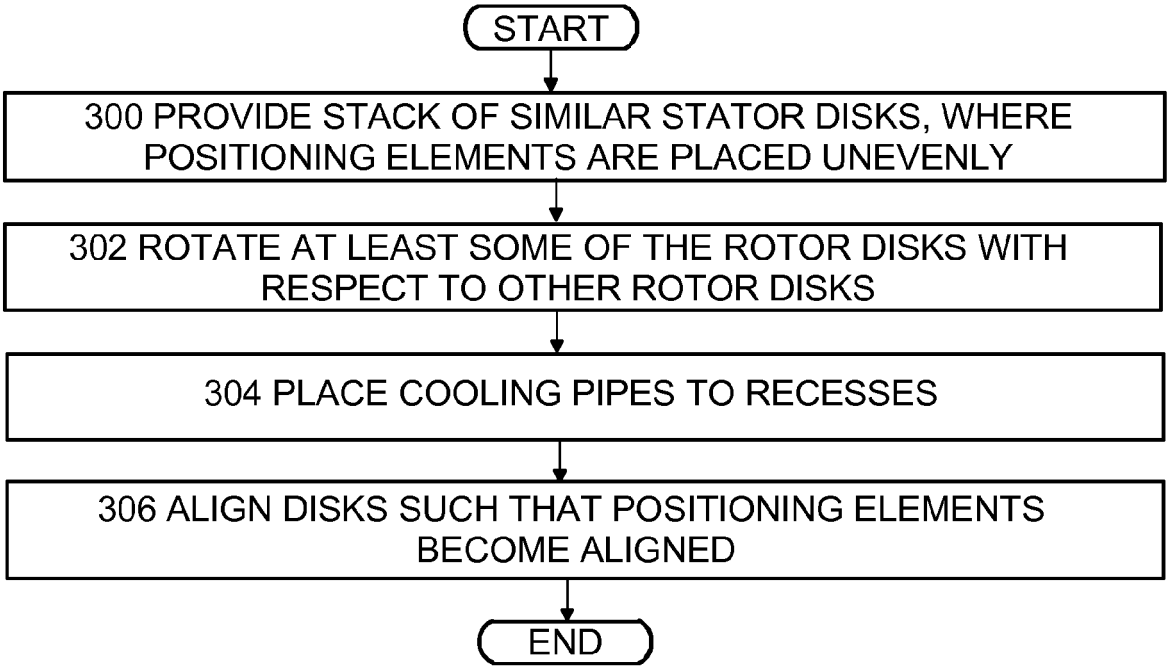
START
300 PROVIDE STACK OF SIMILAR STATOR DISKS, WHERE POSITIONING ELEMENTS ARE PLACED UNEVENLY
302 ROTATE AT LEAST SOME OF THE ROTOR DISKS WITH RESPECT TO OTHER ROTOR DISKS
304 PLACE COOLING PIPES TO RECESSES
306 ALIGN DISKS SUCH THAT POSITIONING ELEMENTS BECOME ALIGNED
END

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 09 17 6739

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H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 December 2010	Le Chenadec, Hervé

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 17 6739

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